Oregon's Tsunami Program

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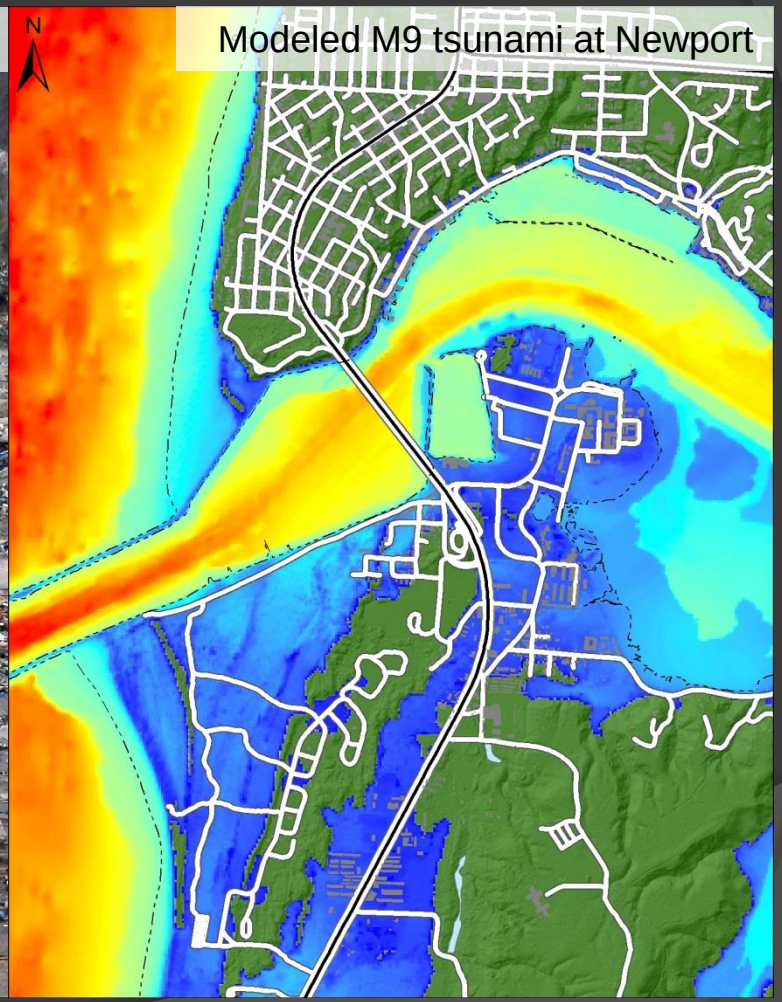
Oregon Emergency management

M9 Tōhoku earthquake & tsunami

PHOTO CREDIT: US NAVY

Modeled M9 tsunami at Newport



VIMS William & Mary Virginia Institute of Marine Science
Oregon State University
NANOOS
University of Oregon
OCMP Oregon Coastal Management Program
NOAA
Warning Guidance Mitigation Hazard Assessment

Key Stakeholders

- Residents (56,506) and visitors (~2-3 x residents in summer);
  48 coastal communities, 10 ports/harbors.

Challenges: ~300 coastal bridges expected to fail, thousands of landslides…communities will be isolated → 2-week ready!

- OEM
  - *NTHMP emergency management rep., Chair – OR Tsunami Advisory Council, responsible for tsunami outreach.*
- DOGAMI
  - *Program lead, NTHMP science rep., mapping & modeling, evacuation modeling, risk assessments, Oregon tsunami clearinghouse.*
- County emergency managers (7);
- Emergency volunteer groups (eg. Nehalem EVC, South Tillamook EVC);
- National Weather Service
  - *Alerts and warnings, maintains TsunamiReady program*
- Northwest Association of Networked Ocean Observing Systems (NANOOS)
  - *maintains NVS Tsunami Evacuation Zones portal (http://nvs.nanoos.org/TsunamiEvac) and TsunamiEvac smartphone app*
- Oregon State University
  - *Geology (paleoseismology), risk assessments, debris modeling*

Our mission…

Oregon's Tsunami Program *Building a Culture of Awareness*

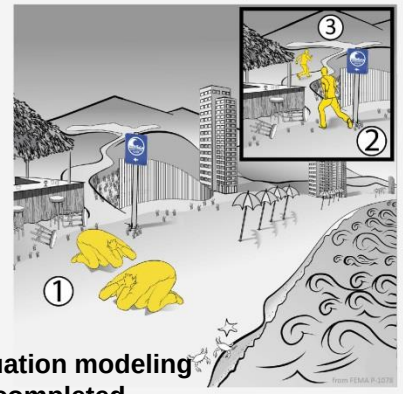
Prepare

Know what to do
- *Attend local outreach events*
- *Know your evacuation route*
- *Assemble an emergency kit*
- *Have a family or business plan*
- *Practice*

Act!

During an earthquake or if you hear a tsunami warning
1. *Drop, cover, and hold during the earthquake*
2. *Follow evacuation signs to high ground*
3. *Stay there until you get the okay from officials; tsunami waves may continue to arrive for several hours*

Goal: instinctive response



Evacuation modeling completed

Education & Outreach

Modeling & Mapping

SB379 tsunami regulatory line established

BEGIN

COMPLETE

Evacuation modeling

2nd generation evacuation maps completed

Beat the Wave evacuation route modeling begun

BEGIN

Beat the Wave & maritime mapping

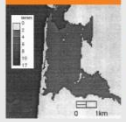
1700 1964 1995 2002 2009 2011 2013 2014 2025 2050

Most recent Cascadia earthquake & tsunami

1964 Alaska earthquake & tsunami hits Oregon coast

Cascadia knowledge (ongoing)

1st generation tsunami mapping begun



2nd generation tsunami modeling begun

Tohuku, Japan tsunami

1st generation maritime mapping begun

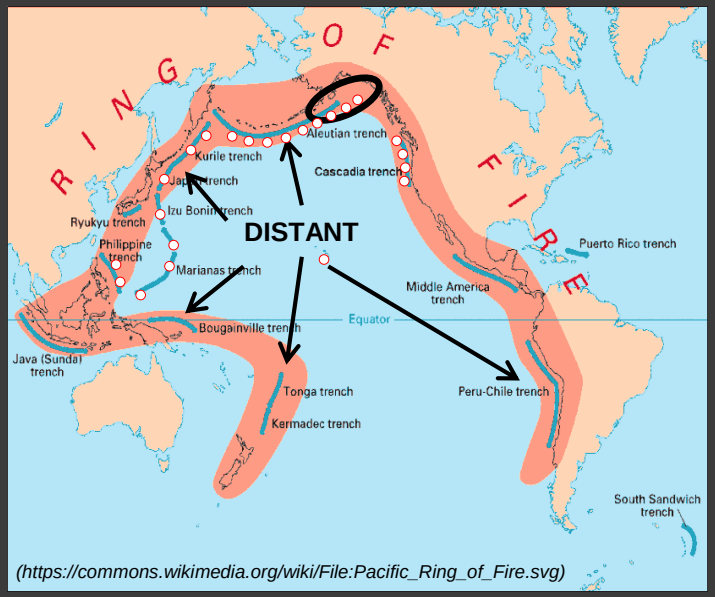
? *Maritime port debris modeling*

? *Landslide modeling*

ASCE7

www.oregontsunami.org

Primer… Distant Tsunamis



(https://commons.wikimedia.org/wiki/File:Pacific_Ring_of_Fire.svg)

- Arrives ~3 hrs 40 mins hours after an eastern Alaska earthquake (~4 hrs south coast)
- Lower damage and flooding than local tsunamis
- Waves reach ~25 ft @ Tillamook Bay, ~39 ft @ Gold Beach
- National Tsunami Warning System can warn you

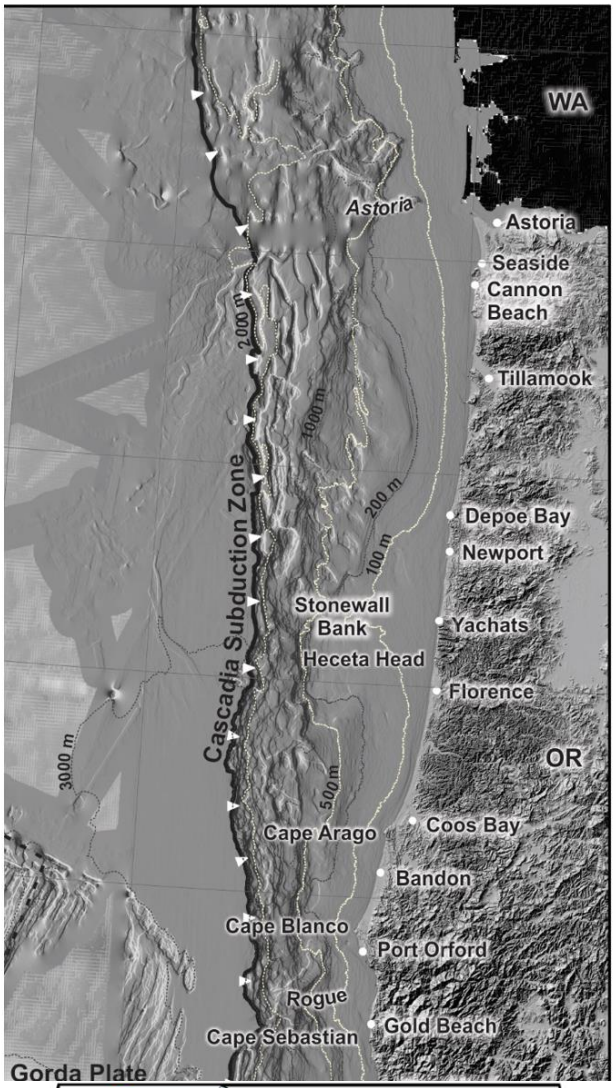
- 29 distant events since the mid 1850s;
- 19 = water levels (WLs) < 0.7 ft – i.e. small…little to no impact to ports and harbors;
- 5 = water levels between 0.7 – 2 ft;
- 5 = water levels > 2 ft;
  - 1873 – Northern California source (10 ft @ Port Orford)
  - 1946 – Unimak Alaska (6 ft @ Clatsop Spit)
  - 1960 – Chile (4.9 ft @ Seaside)
  - **1964 – Anchorage, Alaska (WLs 8.2 – 12.1 ft in estuaries), coincided with high tide.**
  - 2011 – Tohoku, Japan (11 ft @ Port Orford vs. 0.8 ft @ Astoria), coincided with *low tide*

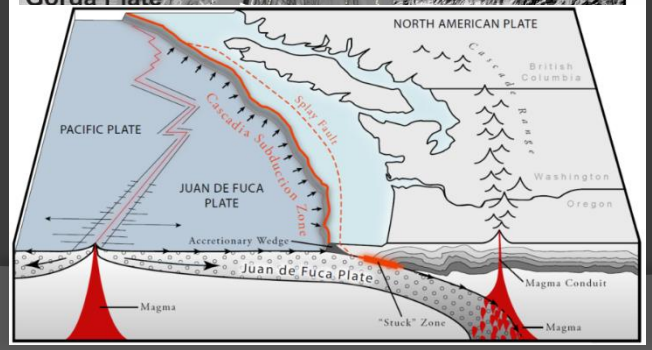
(Data from National Centers for Environmental Information , 2016)

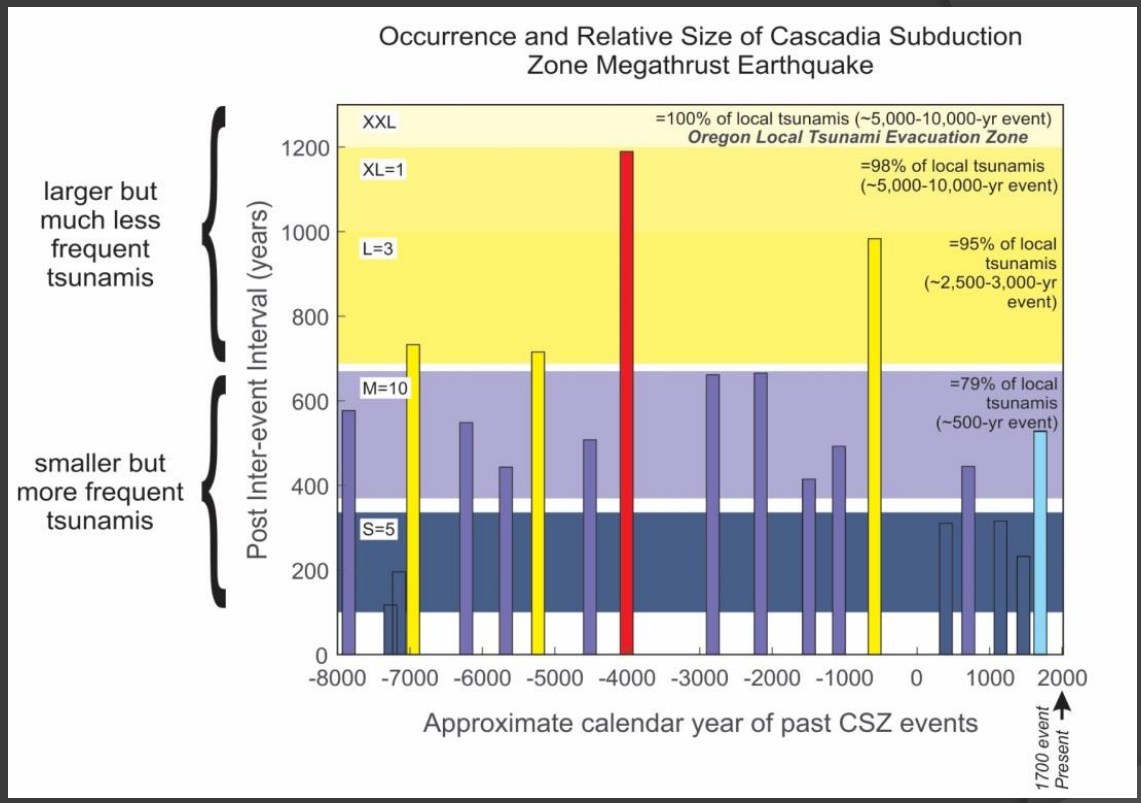
(Allan et al. 2018)

Primer… Local Tsunamis

North American Plate Overrides Juan de Fuca Plate Along Cascadia Subduction Zone at a rate of 1.5 inches/year







10,000 year record of deep sea turbidites, subsidence and tsunami inundation in coastal lakes and estuaries

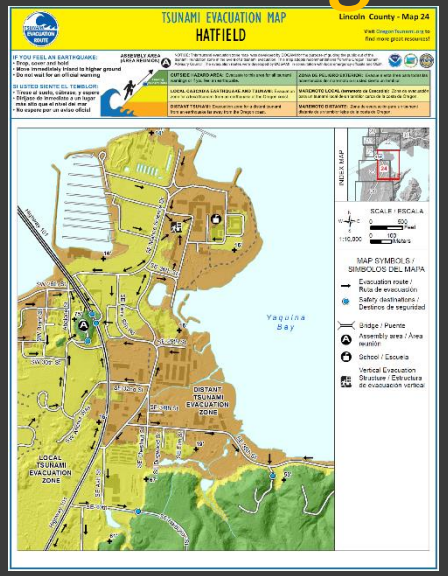
19 = Great earthquakes (> 8.5 Mw)

26 = smaller events (> 7.4, < 8.5 Mw)

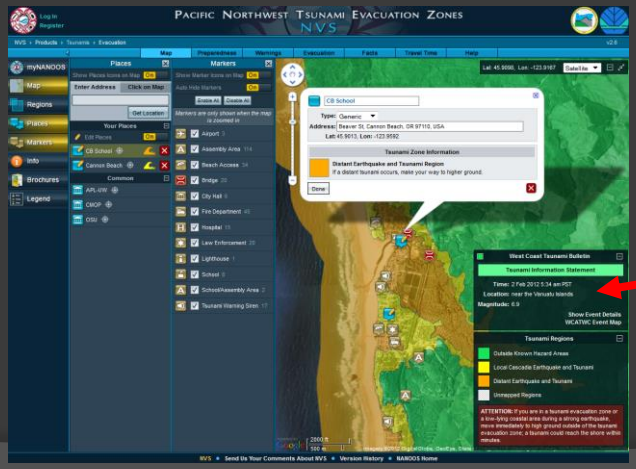
Tsunami waves arrive in minutes!

(Witter et al. 2011; Goldfinger et al., 2012)

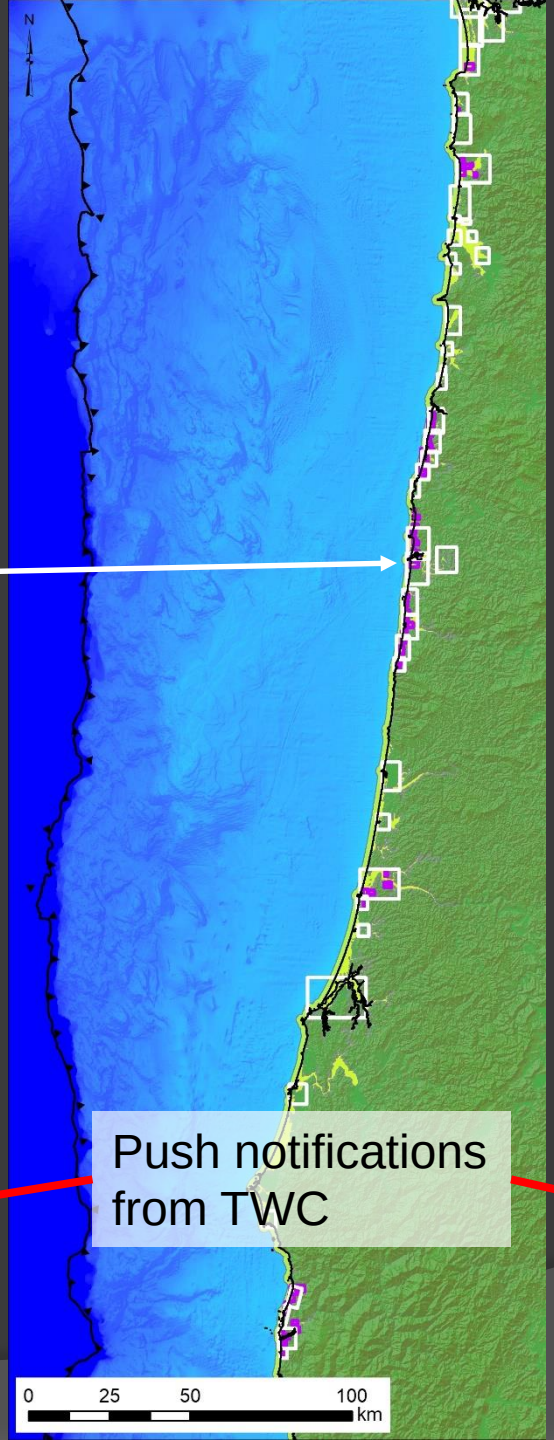
Maps for Preparedness & Planning



Evacuation brochures

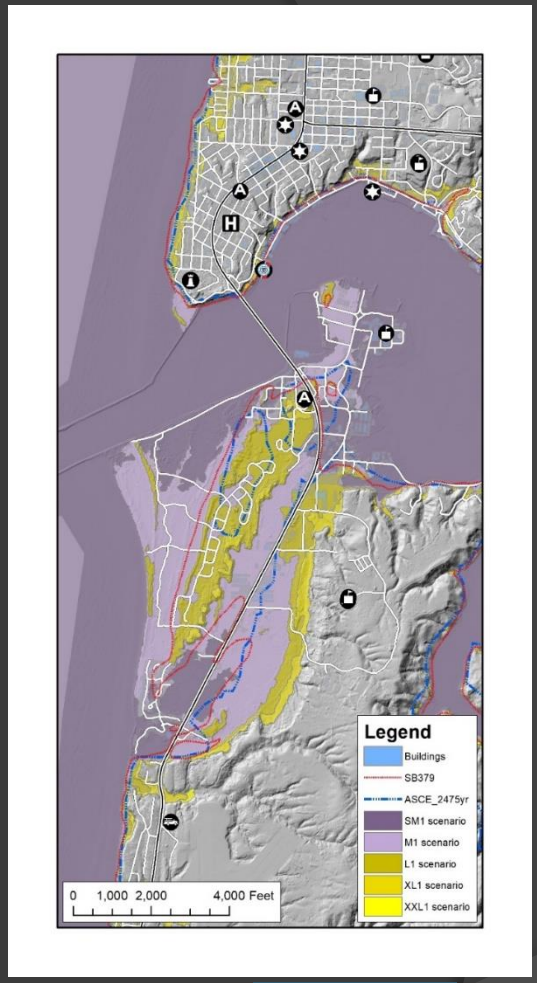


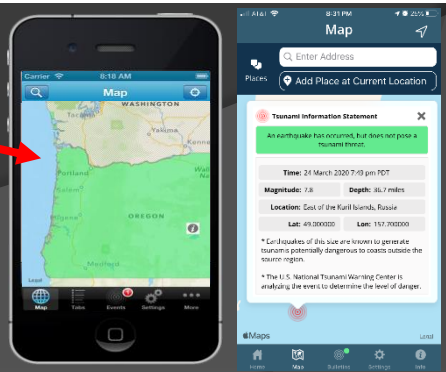
Online evacuation zone viewer



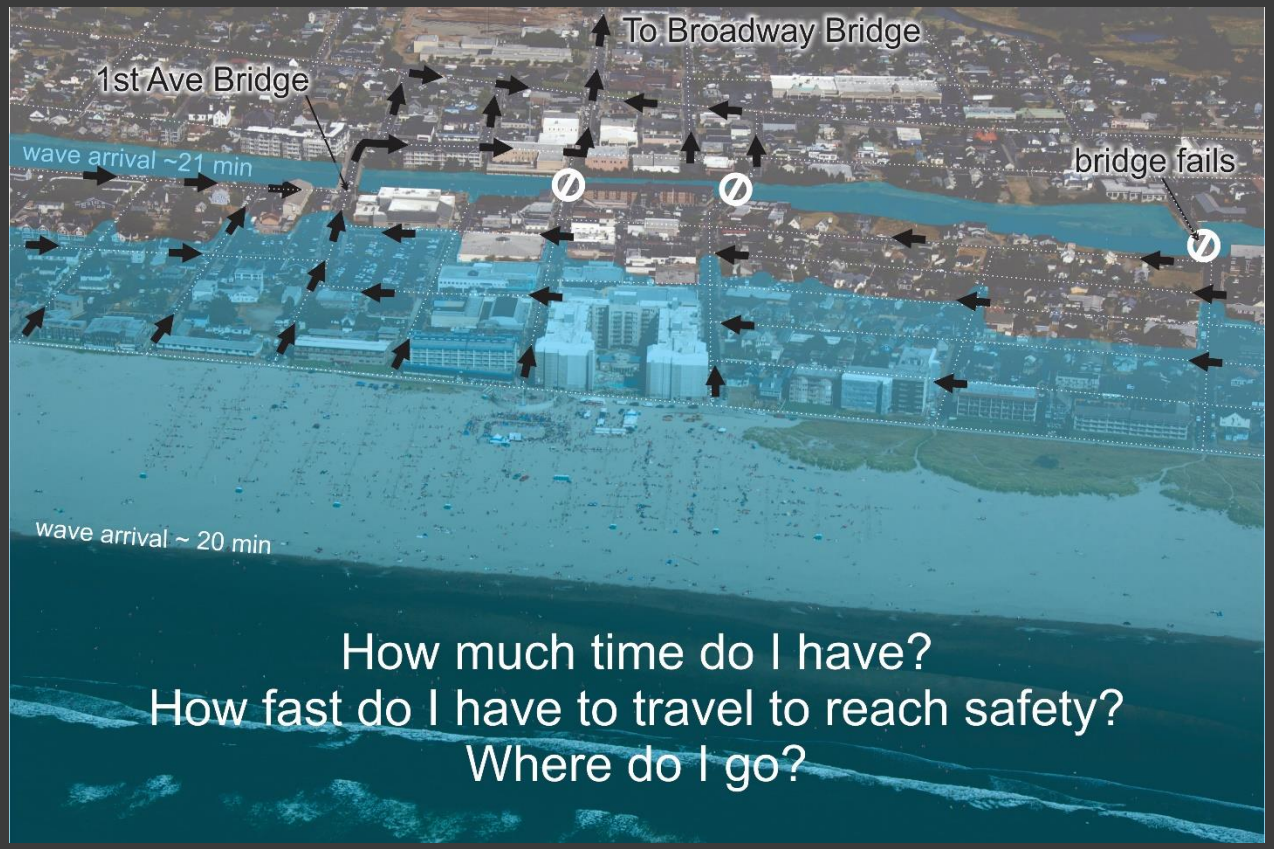
Push notifications from TWC

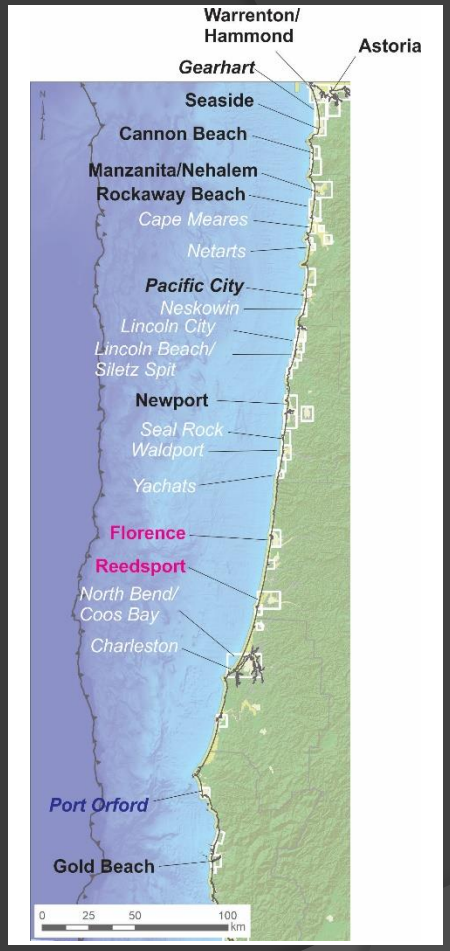
Tsunami Inundation Maps





Evacuation modeling… *Beat the wave*





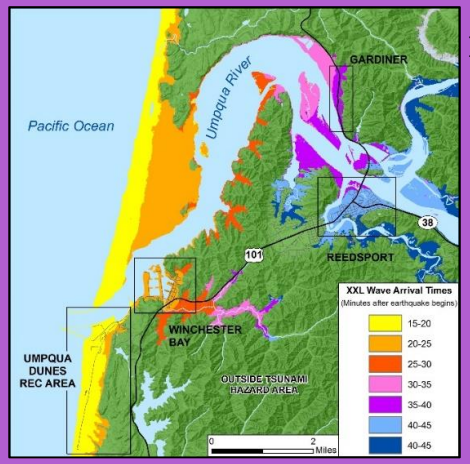
Inputs

- Road and trail surfaces (paved vs gravel vs sand)
- Tsunami evacuation zone (**XXL**)
- DEM for slope and distance (lidar)
- **Tsunami wave arrival times**

Outcomes:

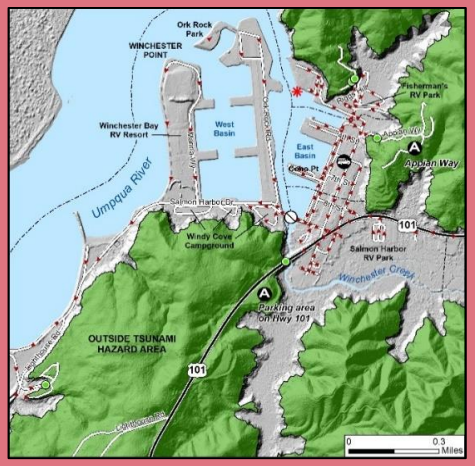
1. Ideal evacuation routes
2. Minimum evacuation speeds
3. Vulnerabilities and mitigation options (primarily infrastructure)
4. Socioeconomic analysis (where are the vulnerable populations?)

“Beat The Wave” Products



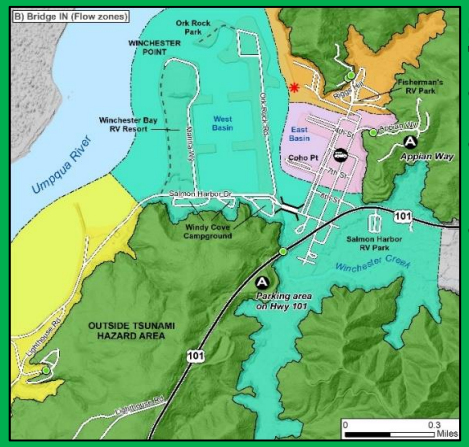
1. Tsunami wave arrival time map

Detailed map of the first tsunami wave arrival for the entire region



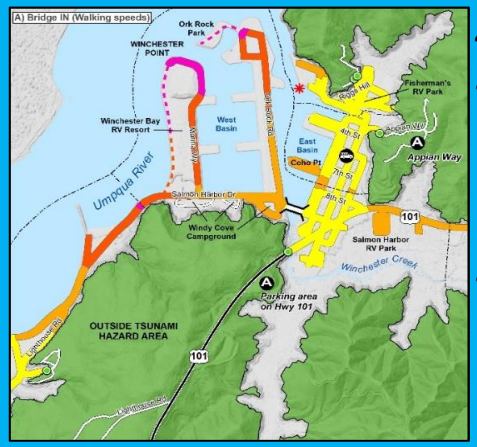
2. Evacuation routes

Detailed information on the most efficient routes to safety (arrows)



3. Evacuation communities

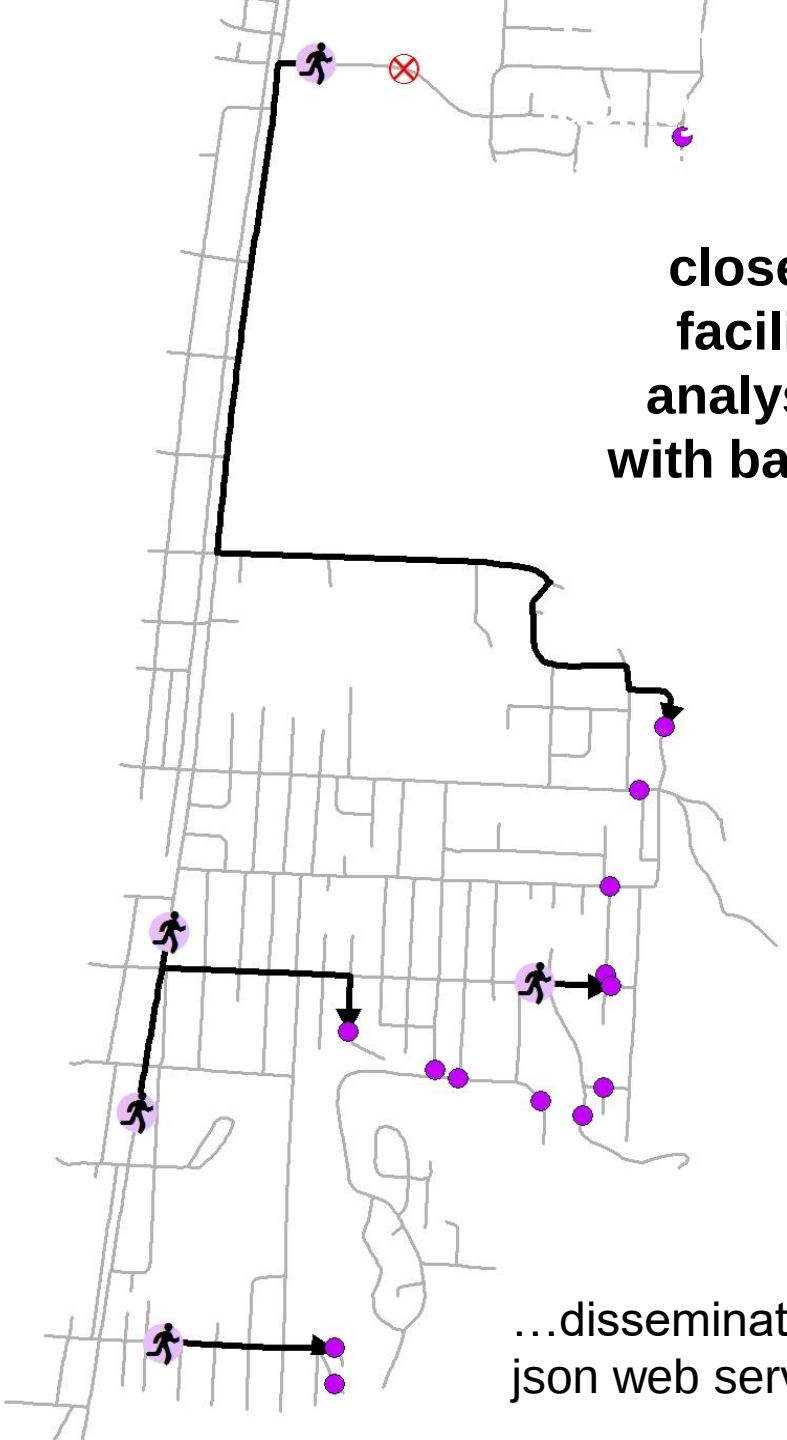
- “flow zones” or “watersheds”
- Zones delineating which safety destination is best for entire town
- These community boundaries will change depending on the scenario (i.e. non-retrofitted bridges out, or adding a vertical evacuation structure)



4. Pedestrian travel speeds

- The MINIMUM walking speed someone must travel in order to reach safety ahead of the first tsunami arrival at the start of their route
- These speeds will change depending on the scenario (i.e. non-retrofitted bridges out, or adding a vertical evacuation structure)

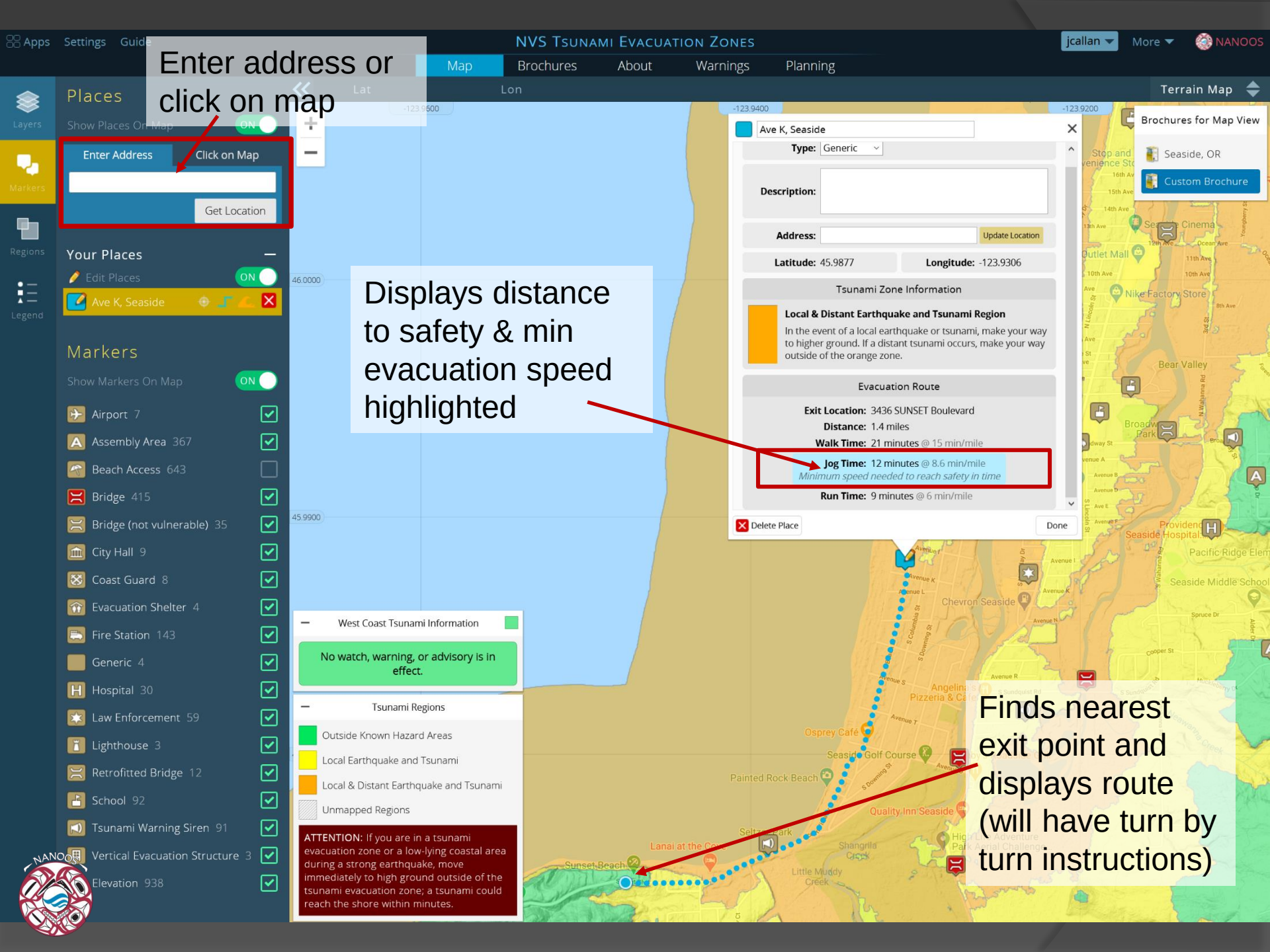
Evacuation modeling benefits… *routable roads = improved evacuation route planning*



closest facility analysis - with barriers

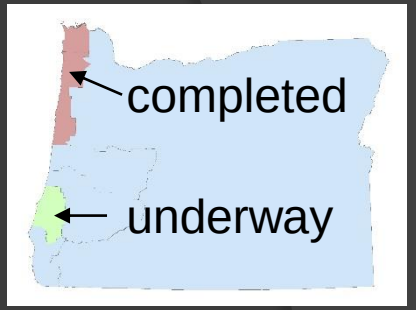
…disseminated via a json web service

UNIVERSITY OF OREGON


Apps
Settings
Guide
NVS Tsunami Evacuation Zones
jcallan
More
NANOOS
Map
Brochures
About
Warnings
Planning
Lat
Lon
Terrain Map
Layers
Markers
Regions
Legend
Places
Show Places On Map
ON
Enter Address
Click on Map
Get Location
Your Places
Edit Places
ON
Ave K, Seaside
Markers
Show Markers On Map
ON
Airport 7
Assembly Area 367
Beach Access 643
Bridge 415
Bridge (not vulnerable) 35
City Hall 9
Coast Guard 8
Evacuation Shelter 4
Fire Station 143
Generic 4
Hospital 30
Law Enforcement 59
Lighthouse 3
Retrofitted Bridge 12
School 92
Tsunami Warning Siren 91
Vertical Evacuation Structure 3
Elevation 938
Enter address or click on map
Displays distance to safety & min evacuation speed highlighted
Finds nearest exit point and displays route (will have turn by turn instructions)
Ave K, Seaside
Type: Generic
Description:
Address:
Update Location
Latitude: 45.9877
Longitude: -123.9306
Tsunami Zone Information
Local & Distant Earthquake and Tsunami Region
In the event of a local earthquake or tsunami, make your way to higher ground. If a distant tsunami occurs, make your way outside of the orange zone.
Evacuation Route
Exit Location: 3436 SUNSET Boulevard
Distance: 1.4 miles
Walk Time: 21 minutes @ 15 min/mile
Jog Time: 12 minutes @ 8.6 min/mile
Minimum speed needed to reach safety in time
Run Time: 9 minutes @ 6 min/mile
Delete Place
Done
Brochures for Map View
Seaside, OR
Custom Brochure
West Coast Tsunami Information
No watch, warning, or advisory is in effect.
Tsunami Regions
Outside Known Hazard Areas
Local Earthquake and Tsunami
Local & Distant Earthquake and Tsunami
Unmapped Regions
ATTENTION: If you are in a tsunami evacuation zone or a low-lying coastal area during a strong earthquake, move immediately to high ground outside of the tsunami evacuation zone; a tsunami could reach the shore within minutes.
-123.9400
-123.9200
46.0000
45.9900
Chevron Seaside
Osprey Café
Seaside Golf Course
Painted Rock Beach
Quality Inn Seaside
Sunset Beach
Little Muddy Creek
Shangrila Creek
Bear Valley
Seaside Middle School
Pacific Ridge Elem
Seaside Hospital
Outlet Mall
Nike Factory Store

Tsunami Building Damage and Casualty Estimation

Goal: *Analyze community exposure to tsunami inundation in order to determine estimates of infrastructure damage and casualty numbers for Clatsop, Tillamook and Lincoln Counties.*



M_W 9.0 earthquake, 11 March 2011

Iwaki, Fukushima, Japan

Ofunato, Japan

Process Overview

WHAT'S AT RISK ?

BUILDINGS
- Usage
- Type

PEOPLE
- How many
- Where
- When (time of day and year)
- Who (Demographics)

WHAT'S THE HAZARD ?

EARTHQUAKE
- Ground Shaking
- Ground Failure

TSUNAMI
- Time of Arrival
- Extent
- Depth
- Momentum Flux

ANALYSIS

v4.2 earthquake model
v4 tsunami model

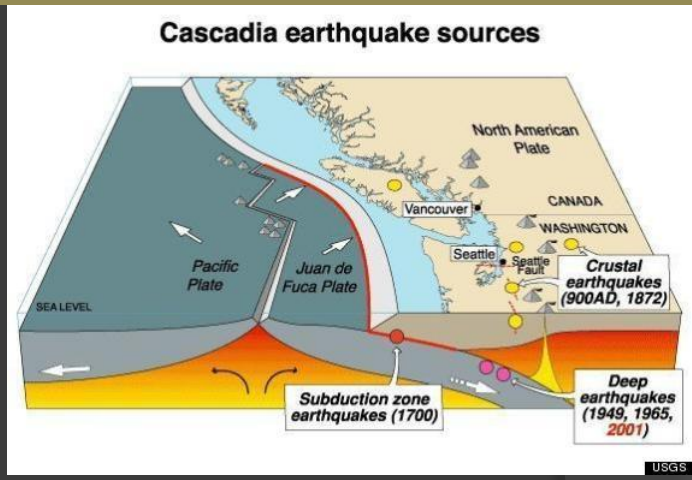
- includes landslides
- includes liquefaction

WHAT'S THE IMPACT ?

LOSS ESTIMATES

- Buildings
- Casualties
- Displaced Population
- Debris

Natural Hazards



Earthquake Scenario: Cascadia M_W 9.0
Ground Shaking: Site Amplification
Ground Deformation: Liquefaction and Landslide Susceptibility

Tsunami Scenario (3 scenarios: M1, L1, XXL)
Building Damage Model: Momentum Flux and Flow Depth
Casualty model (Injuries + Fatalities): Flow Depth
Considerations: community preparedness (e.g. signs/drills, knowledge, milling behavior, route failures, vertical evacuation).

Hazus : Estimates the damage to a "typical" building type (e.g. a wood-frame structure)
- *We can define building damage/losses well*
- *We can define the permanent resident population pretty well*
- *Problem is estimating the non-permanent population (scenarios)*

Population Modeling

> A “2 AM” scenario where most people are in a residential structure (including tents, RVs, boats etc.)

We differentiate between “permanent” residents versus “temporary” visitors. Why?

- Oregon coast is a hub for recreational activities (lots of visitors). Hotels, motels, vacation rentals, campgrounds located close to the ocean and hence the tsunami hazard.
- Visitors largely ignorant of the hazard
- Potential of underestimating casualties
- Communities need these data for mass care planning

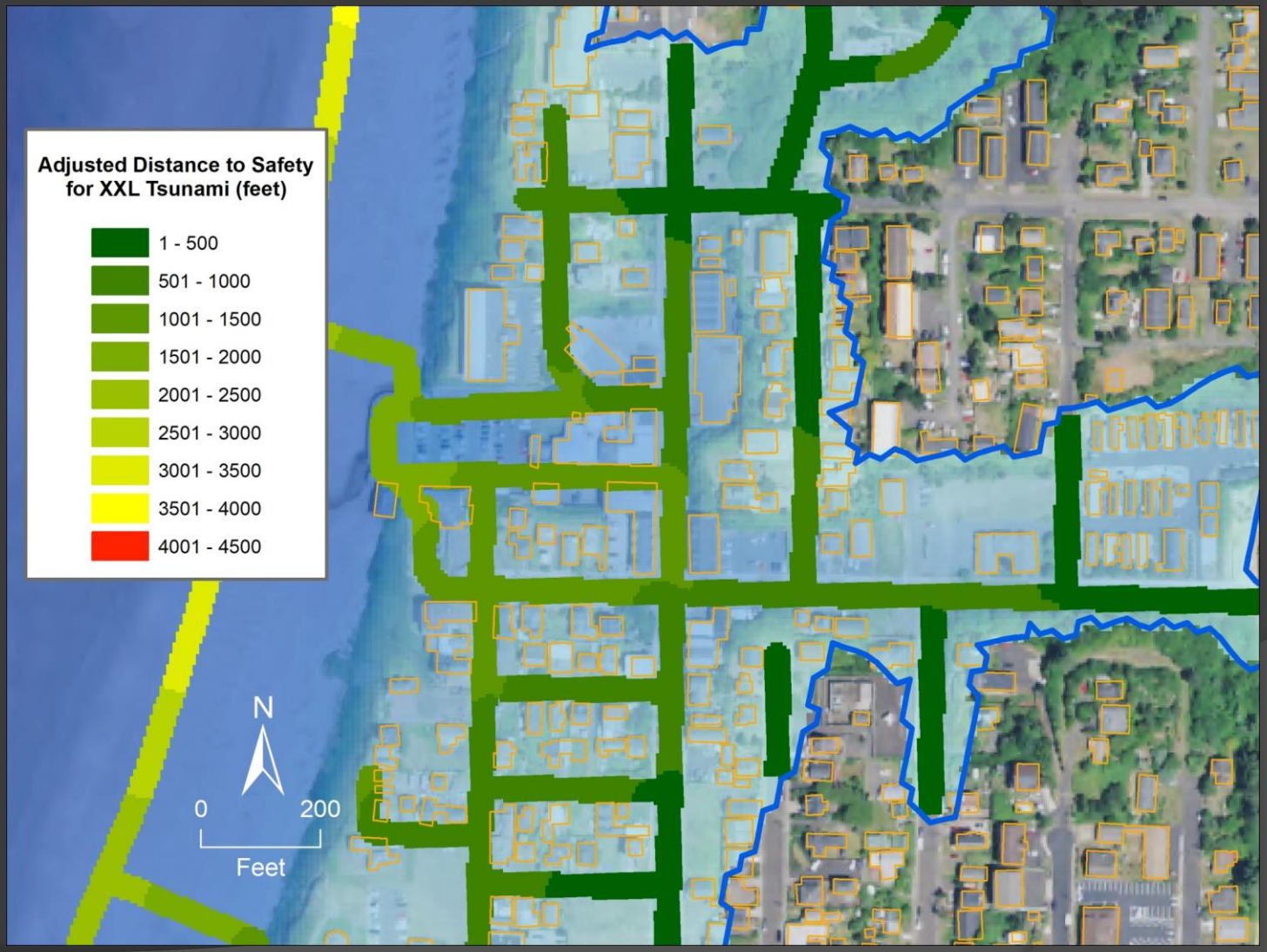
Also, differentiates between <65 years & > 65 years

Casualty Modeling

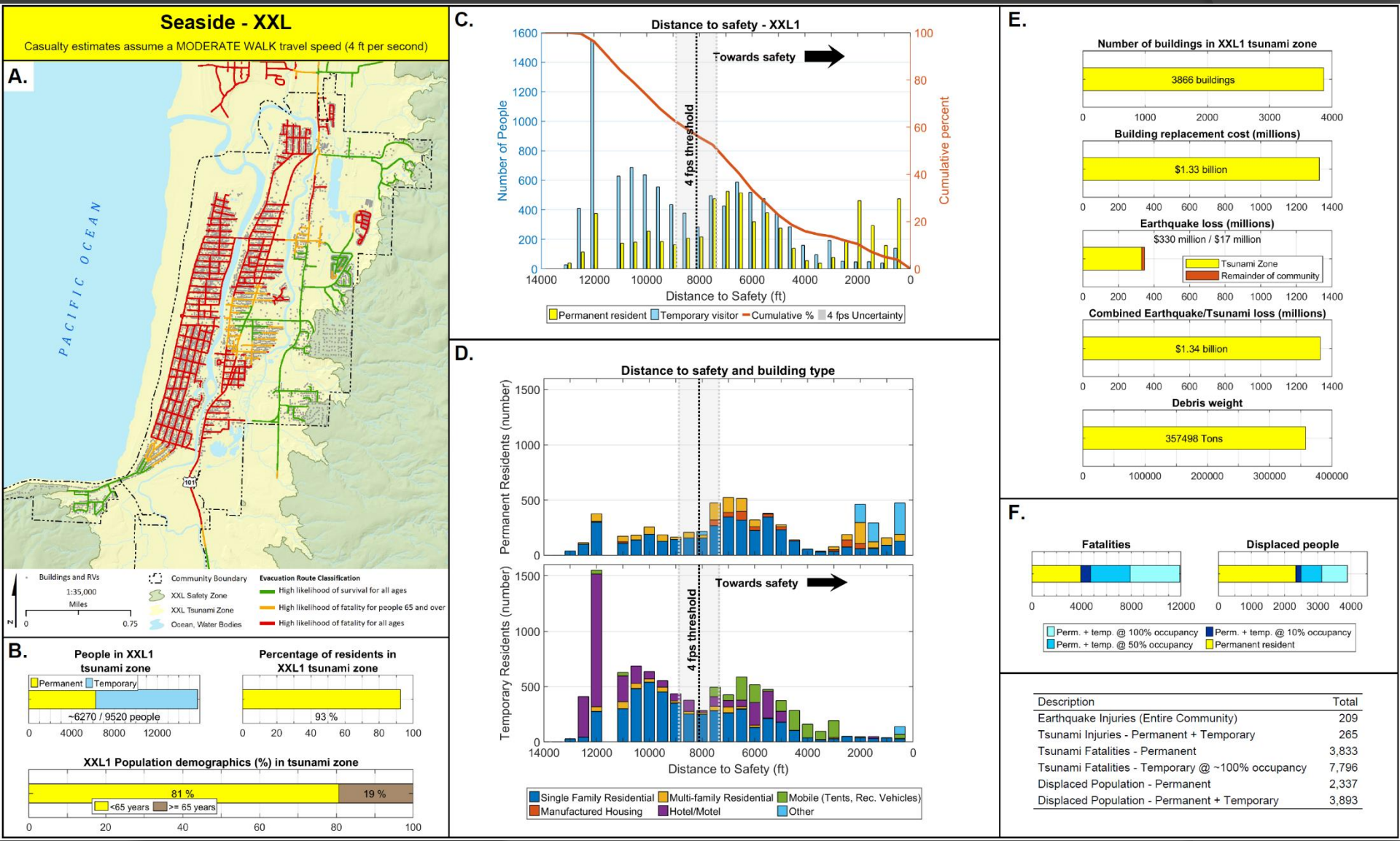
Populate buildings with people (summertime weekend, wintertime mid-week)

Calculate "Distance to Safety" for each building's occupants ("Beat the Wave")

Run FEMA Hazus Tsunami Casualty Model

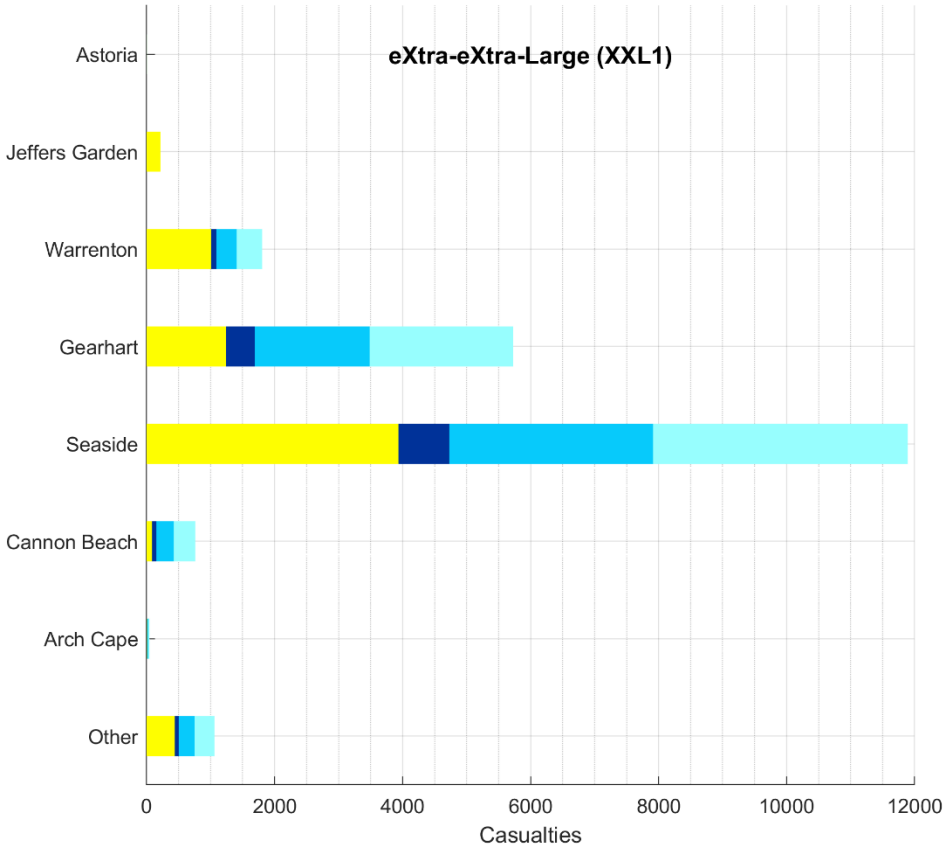


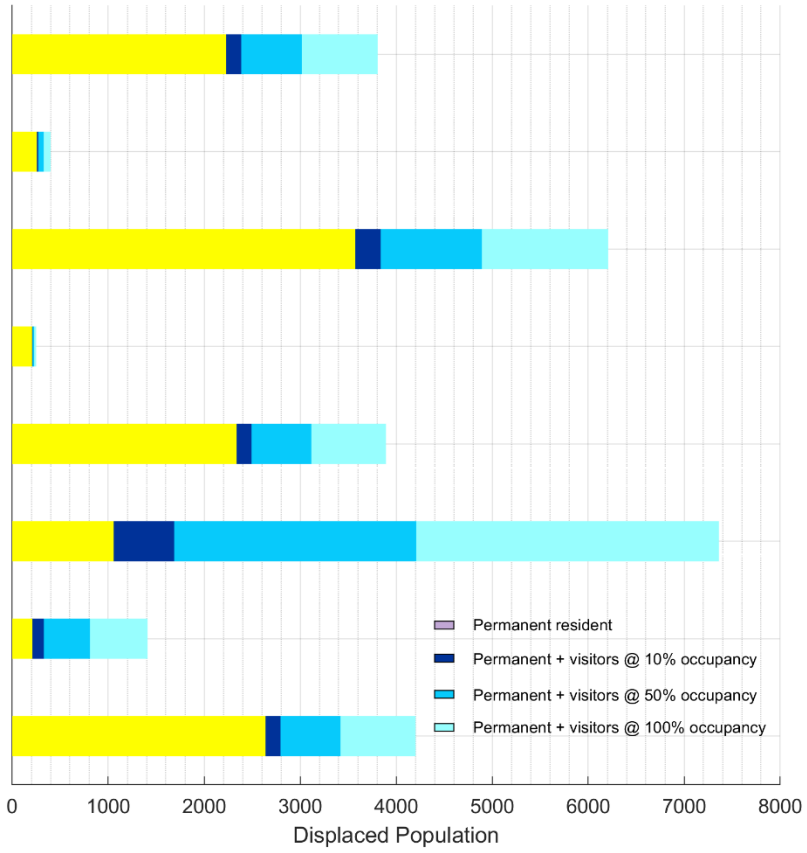
Community Profile Sheets



Description	Total
Earthquake Injuries (Entire Community)	209
Tsunami Injuries - Permanent + Temporary	265
Tsunami Fatalities - Permanent	3,833
Tsunami Fatalities - Temporary @ ~100% occupancy	7,796
Displaced Population - Permanent	2,337
Displaced Population - Permanent + Temporary	3,893

Results – Casualties and Displaced Population





Earthquake deaths are generally low
Cascadia tsunami fatalities are high. Estimates based on 3 counties indicate ~4,100 to 13,800 (M) and 8,500 to 32,400 (XXL); larger #s include visitor estimates.

Oregon Office of Emergency Management

- Be 2 Weeks Ready
- Tsunami Debris Guide
- ShakeAlert